NOAA/AOML Ocean Observational and Modelling Capabilities

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Silver Spring, MD
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NOAA/AOML Existing Observational Capabilities

Argo floats (US DAC)

XBT Network (15 repeat transects)

PIRATA Array (North East Extension)

Surface drifters

Western Boundary Time Series

Repeat hydrography cruises

South Atlantic Meridional Overturning Circulation (IES, PIES)

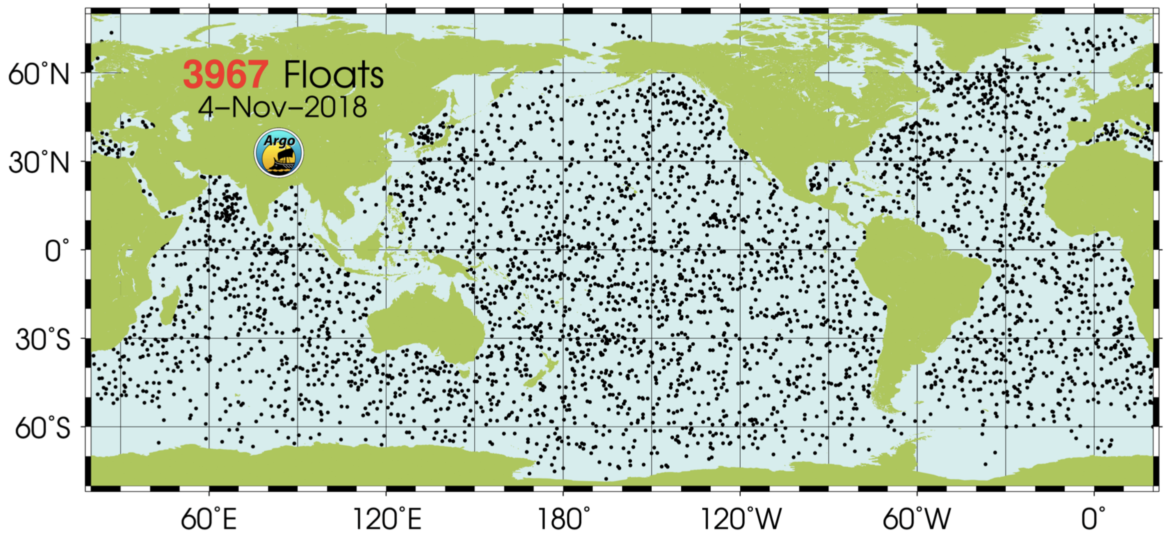
Underwater Gliders (NOAA hurricane gliders)

Relevance to this meeting:

- Observations to monitoring indicators of key ocean features (and detect extremes)
- Observations to monitor and study coastal environments (sea level changes)
- Observations to understand processes and model assessments (extreme weather outlooks and forecasts)

Argo Profiling Floats

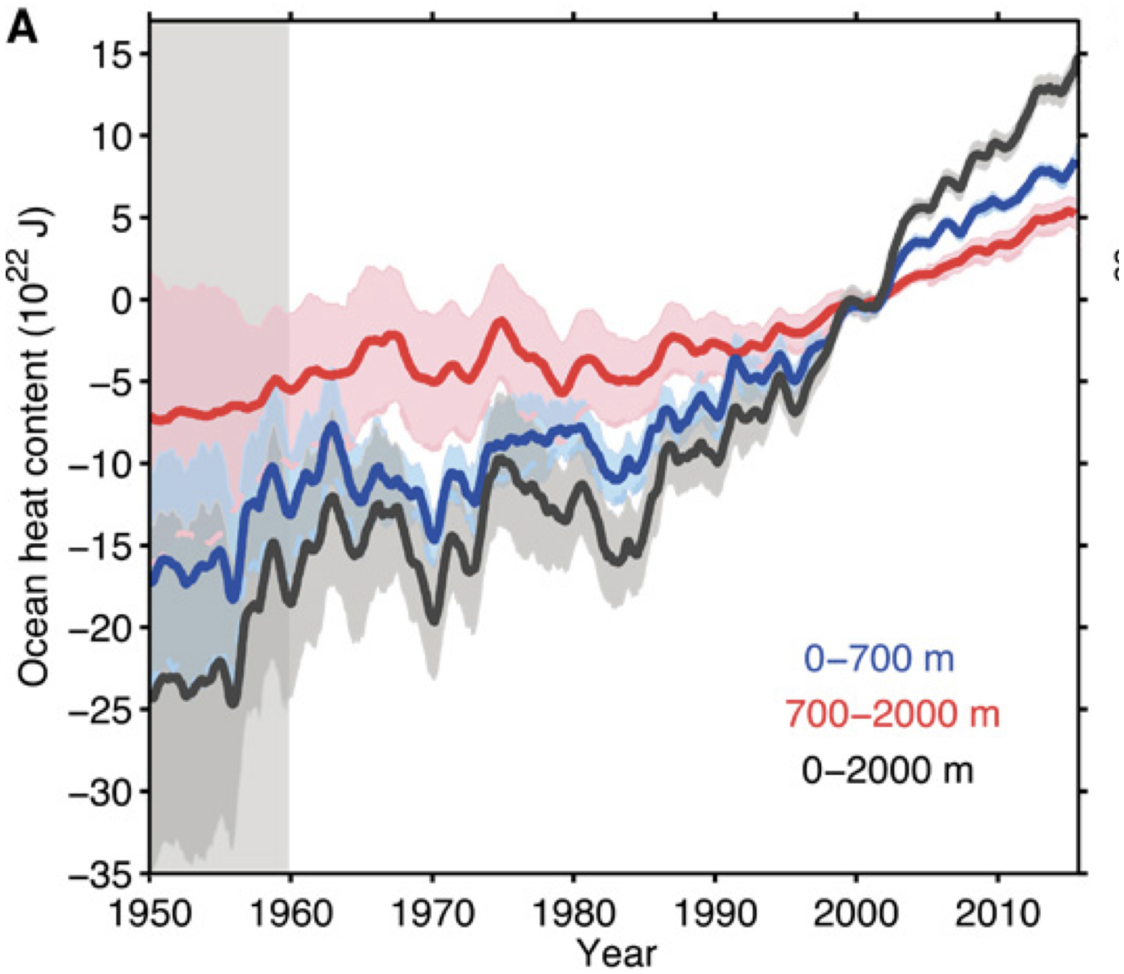
Identifying contribution of deep ocean to heat content



~150k profiles per year
www.argo.ucsd.edu

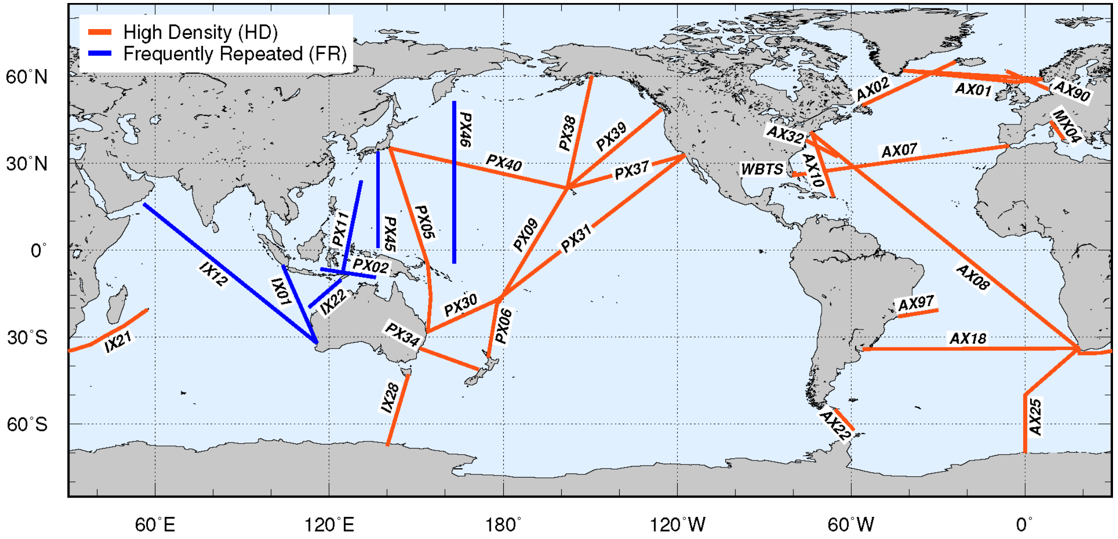
The rate of heat storage in the upper 2000m changes is larger at 0-700m than 700-2000m.

All ocean basins have experienced significant warming since 1998, with greatest warming in the southern oceans, tropical/subtropical Pacific Ocean, and tropical/subtropical Atlantic Ocean. **We need climate models that represent this.**



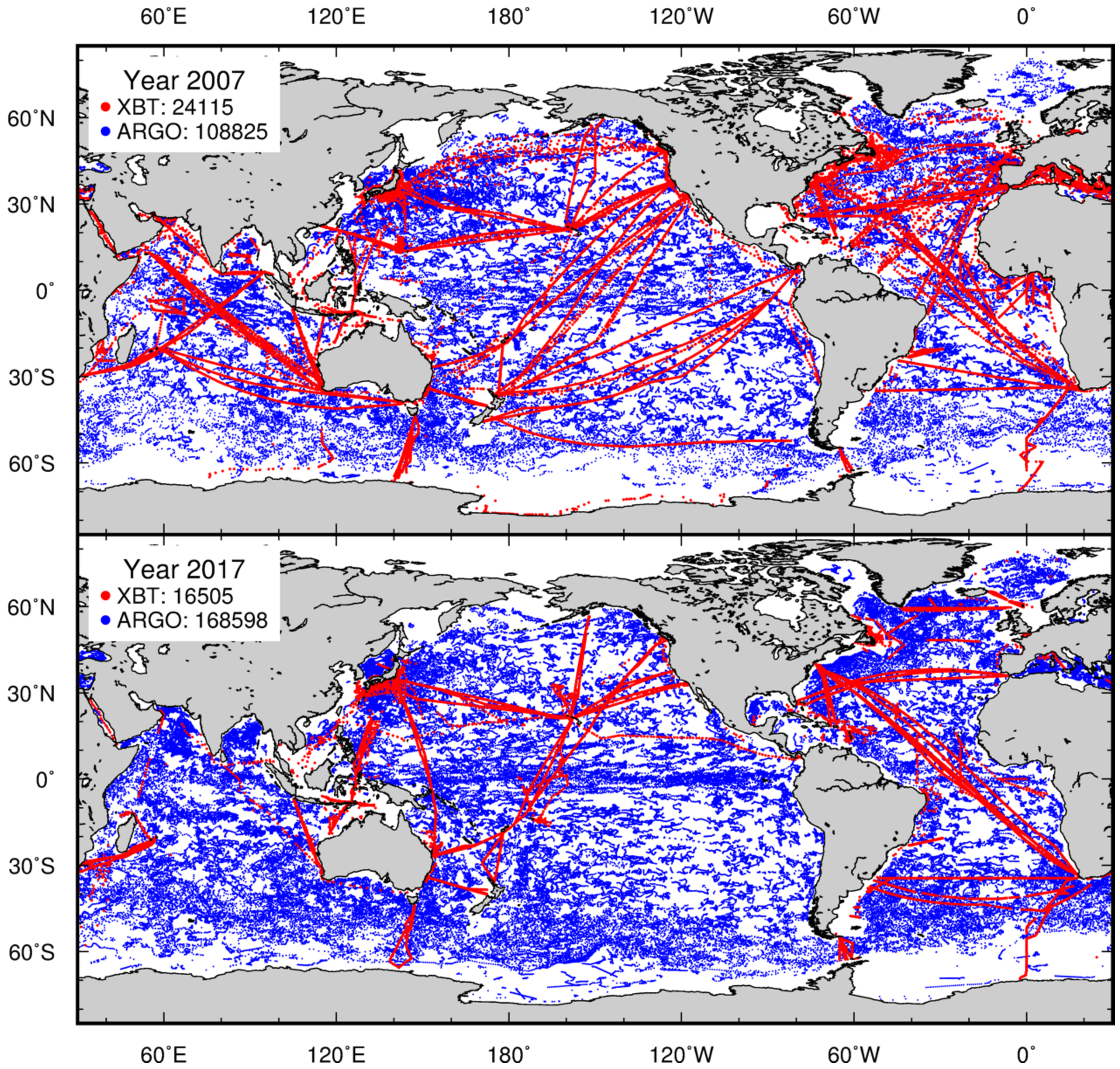
Cheng et al, 2015

Global XBT Network



30 repeat temperature sections (to 800m depth; ~20k profiles per year) for:

- **Boundary currents, surface currents, subsurface currents**
- **Meridional heat transports**
- Upper ocean heat content

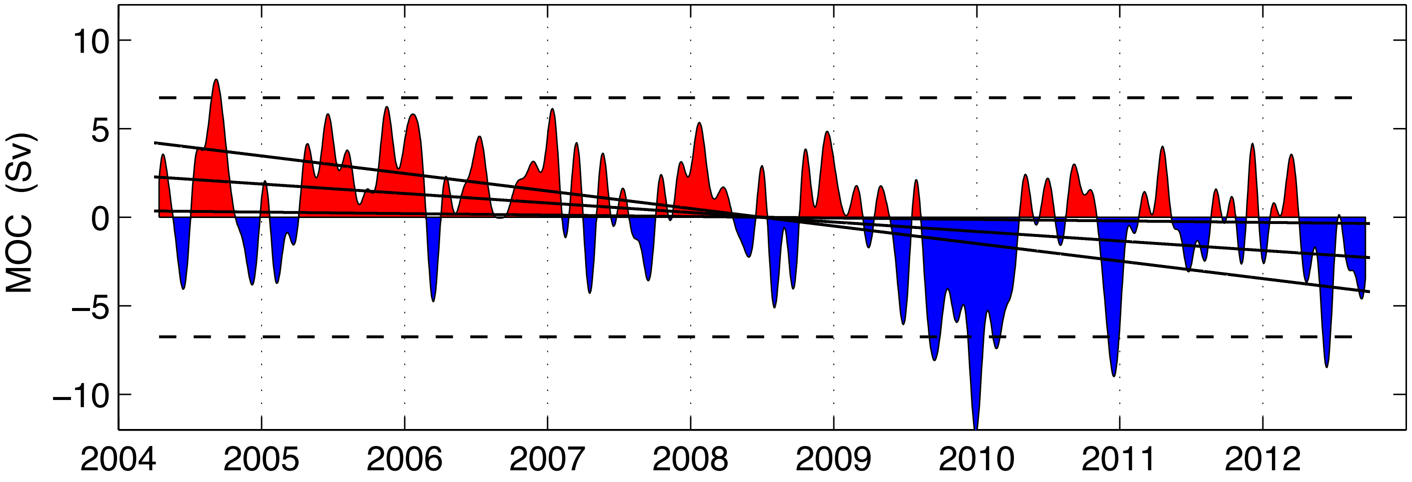


Goni et al, 2019

Increased Understanding of MOC from AOML's 26N Array

Magnitude and variability of the MOC and associated heat flux

- Short-term variability of the transport
- Seasonal cycle of the MOC
- Inter-annual variability
- Multi-year trend

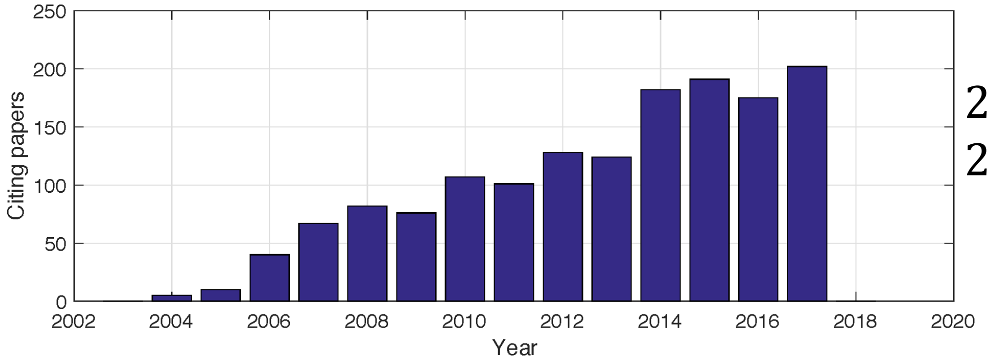


AMOC Anomalies (positive is northward) relative to mean annual cycle (Smeed et al. 2013)

Processes

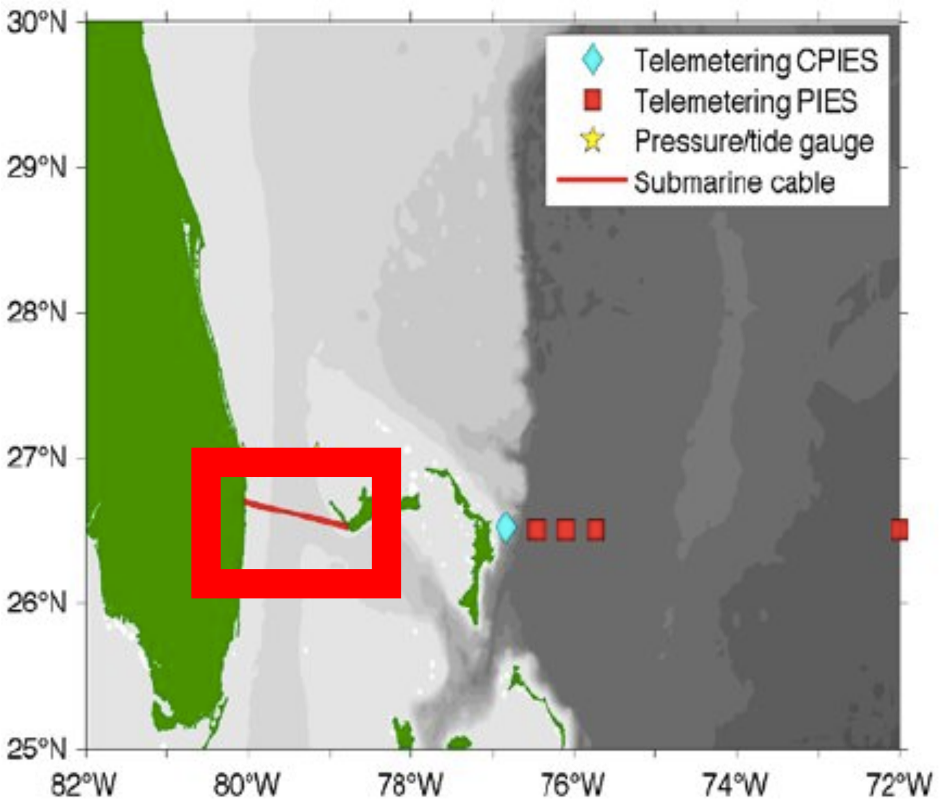
- Components of the MOC
- Vertical structure of MOC
- Relative importance of overturning and gyre circulation
- Impacts of eddy processes

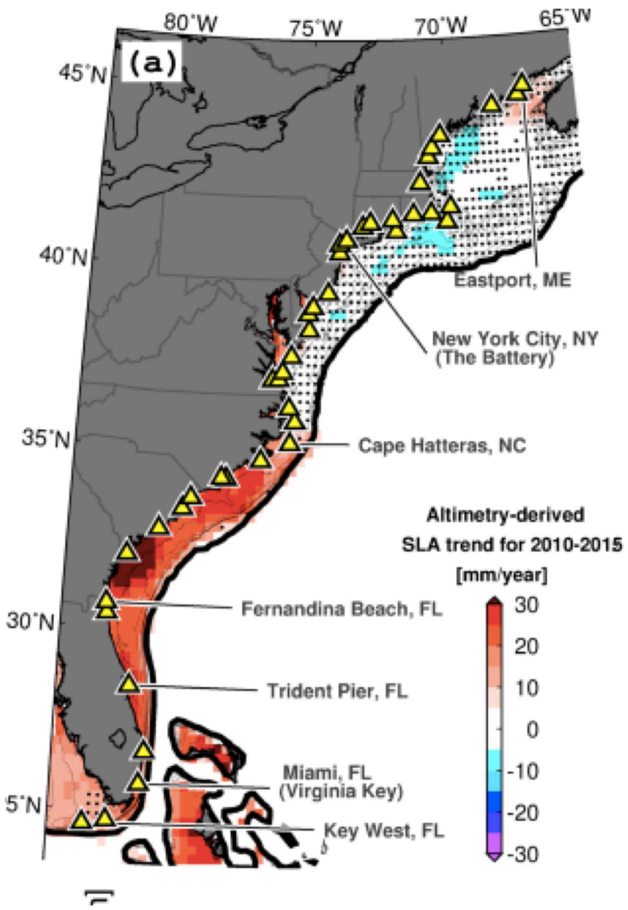
Rapid/MOCHA/WBTS Collaboration between NOAA, NSF and NERC/UK influences researchers

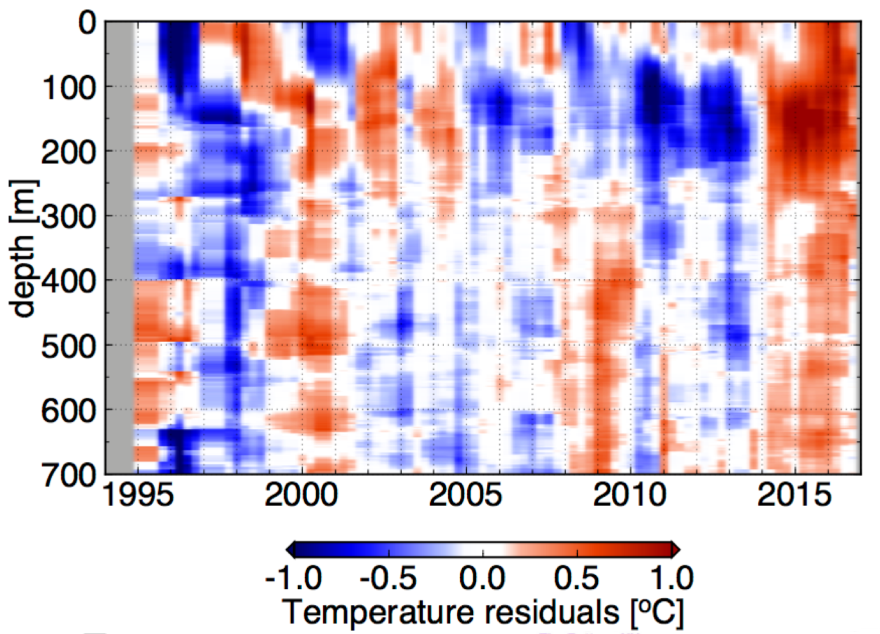


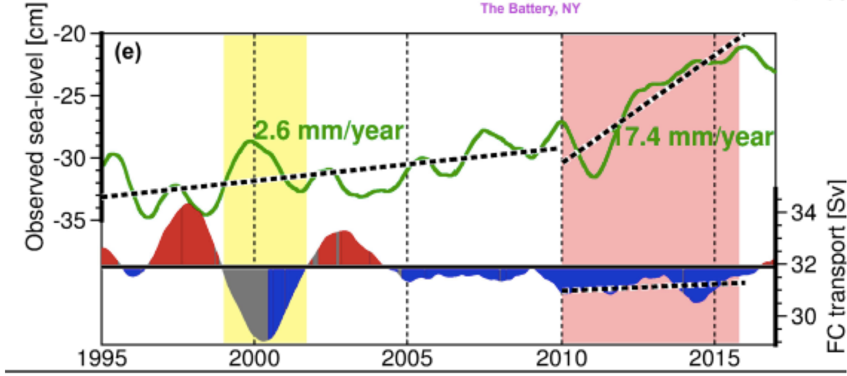
200 citations in 2017

Western Boundary Time Series (Florida Current)







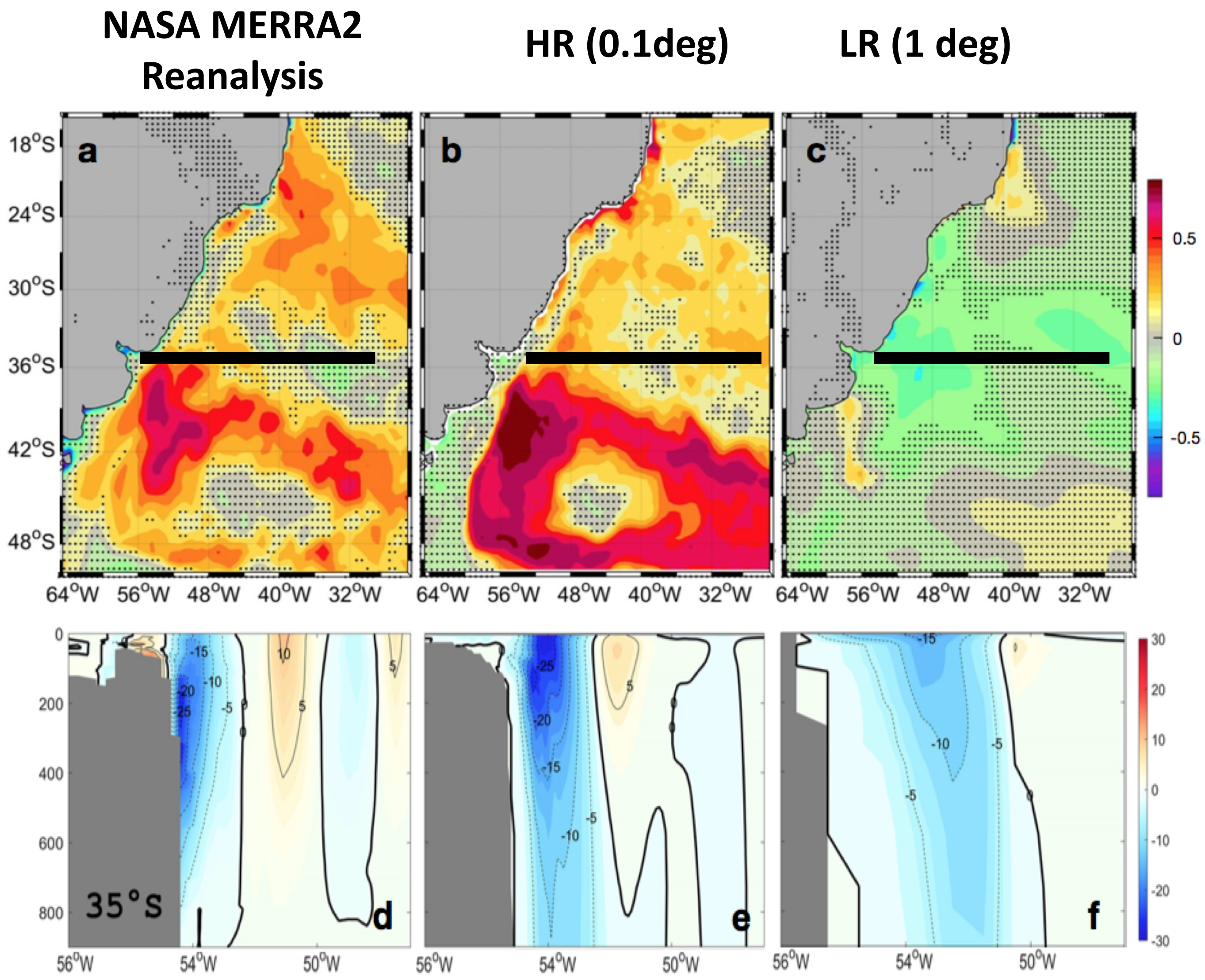


XBTs , CTDs, dropsondes observations

Satellite altimetry and tide gauge observations along the east coast of the US has shown that the rate of SL change is >0 south of Cape Hatteras.

Hydrographic data supported by NOAA shows that changes in the Florida Current transport and upper ocean warming are responsible for most of these changes.

Assessment of Coupled CCSM4 (100 yr couple) Model

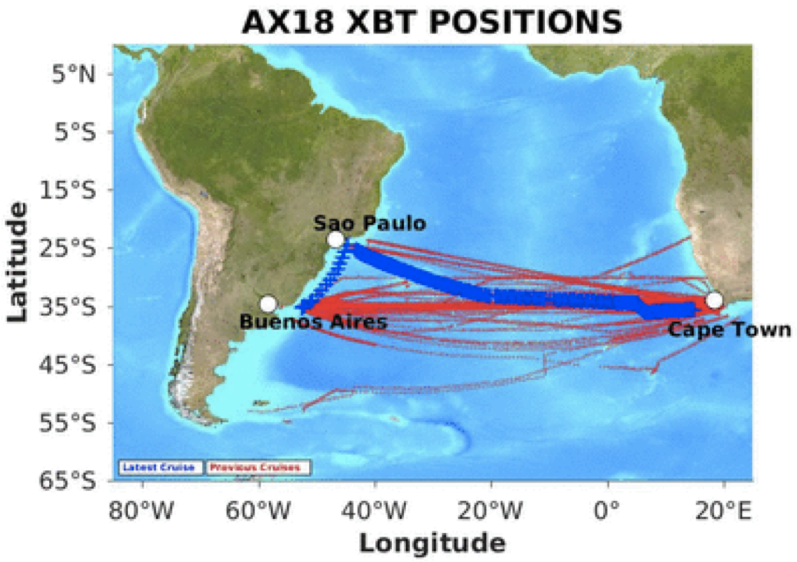


Goes, 2019

Model resolution evaluation using in situ observations

- **(upper) Positive Correlation between SST and Latent HF shows strong air-sea coupling in OBS and HR. LR behaves like a slab ocean.**
- **(Lower) Brazil Current in LR weaker wider and deeper than XBT OBS at 35°W – weaker ΔT.**
- **Why is this important ? The Brazil Current is the mechanism by which upper waters are taken from subtropical to subpolar regions in the South Atlantic.**

South Atlantic MHT Observations/Estimates



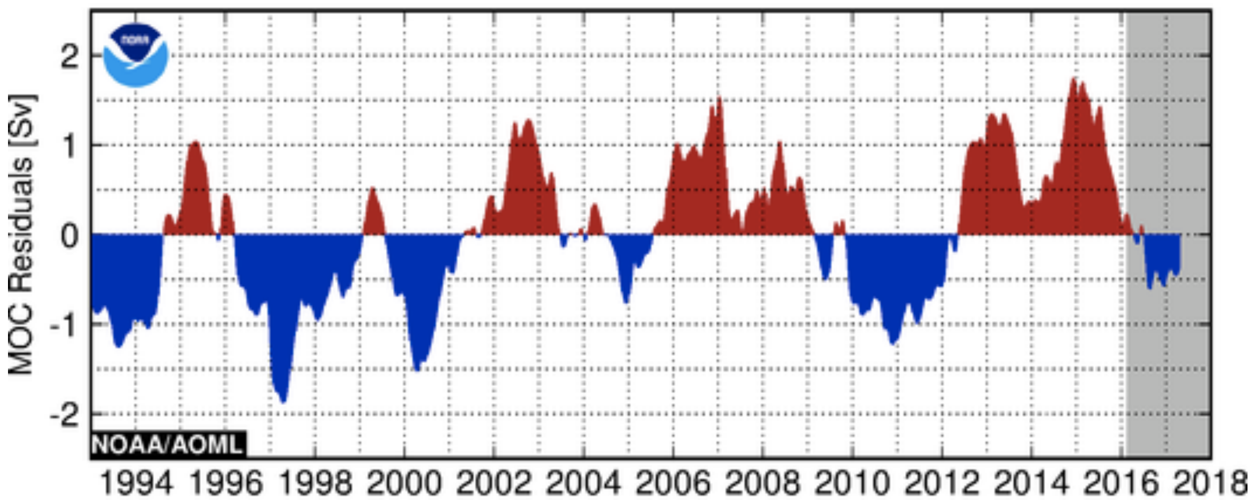
50+ temperature sections since 2002
Longest record of in situ MHT estimates

Key results:

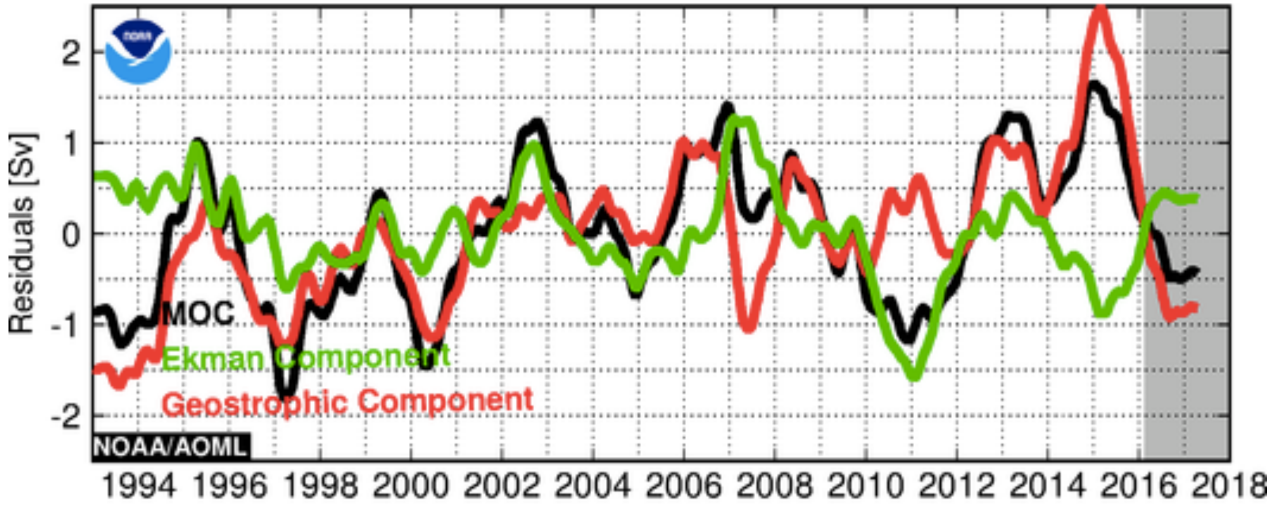
The MOC/MHT in the South Atlantic currently has values below average.

MOC/MHT dominated by density field or wind field during different year periods.

South Atlantic MOC Residuals at 34.5ºS



residuals = anomalies with respect to the seasonal cycle
1 Sv = 10^6 m^3 s^{-1}

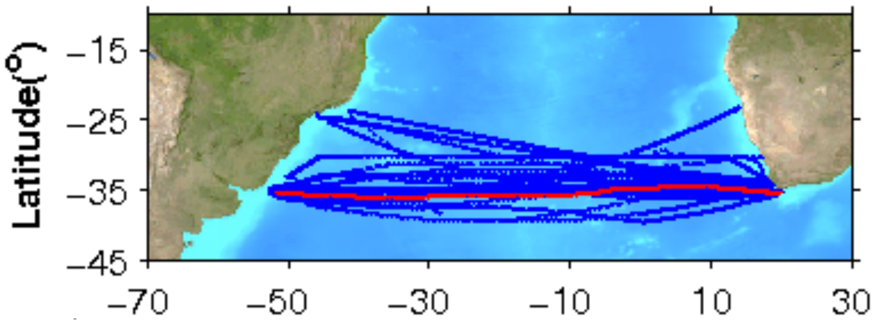


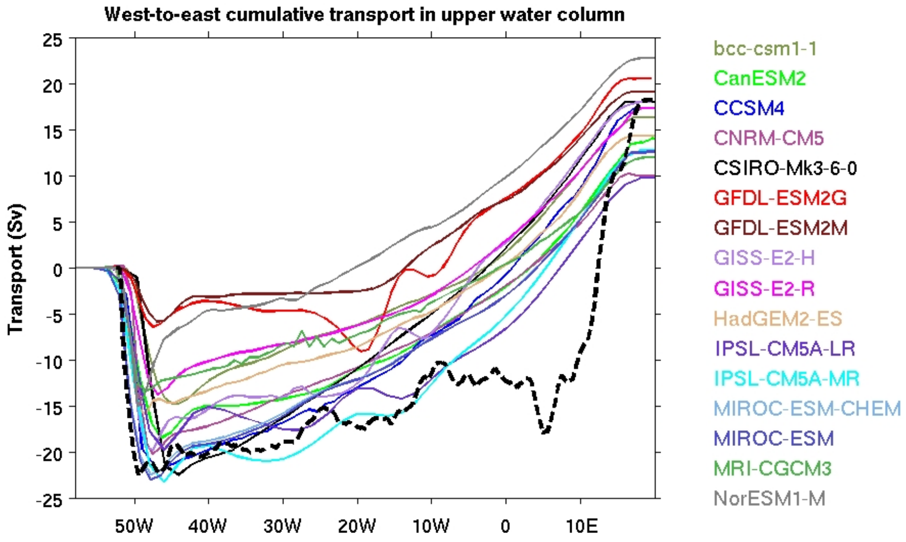
MOC values displayed are filtered using a 13 months low-pass filter
1 Sv = 10^6 m^3 s^{-1}

www.aoml.noaa.gov/

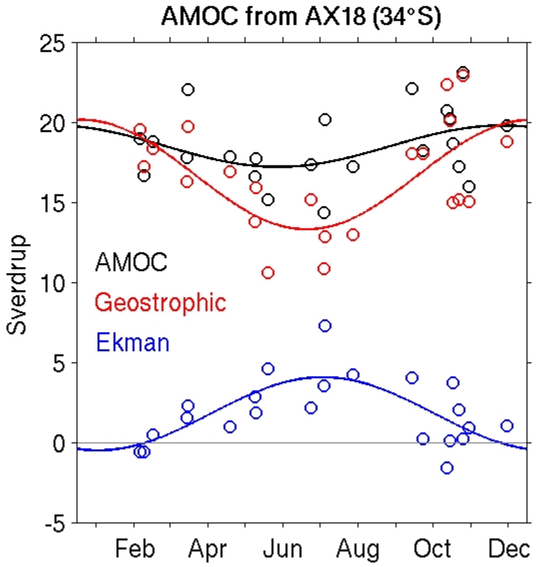
Evaluation of Numerical Models (AMOC)

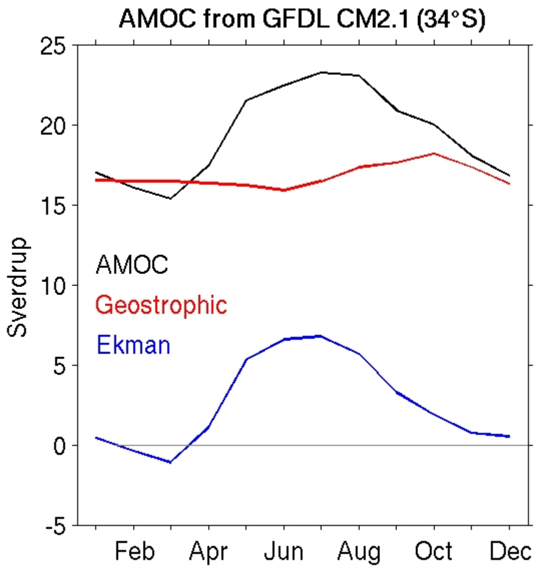
AX18 XBT transect





West-to-east cumulative volume transport in the upper layer: AX18 XBT transect (black dashed), CMIP5 models (colored lines)

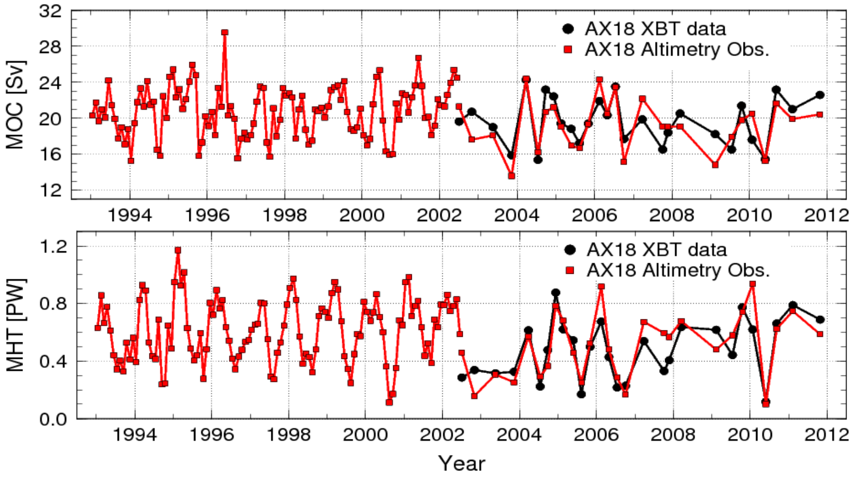




- **In situ observations indicate that both geostrophic and Ekman transports experience annual cycles, but they are out of phase.**
- **The Annual cycle in the modeled (GFDL-CM2) MOC is dominated by Ekman component, and the geostrophic component shows little seasonal variations.**
- **The misrepresentation of the seasonal variations may be related to lack of representation of boundary currents.**

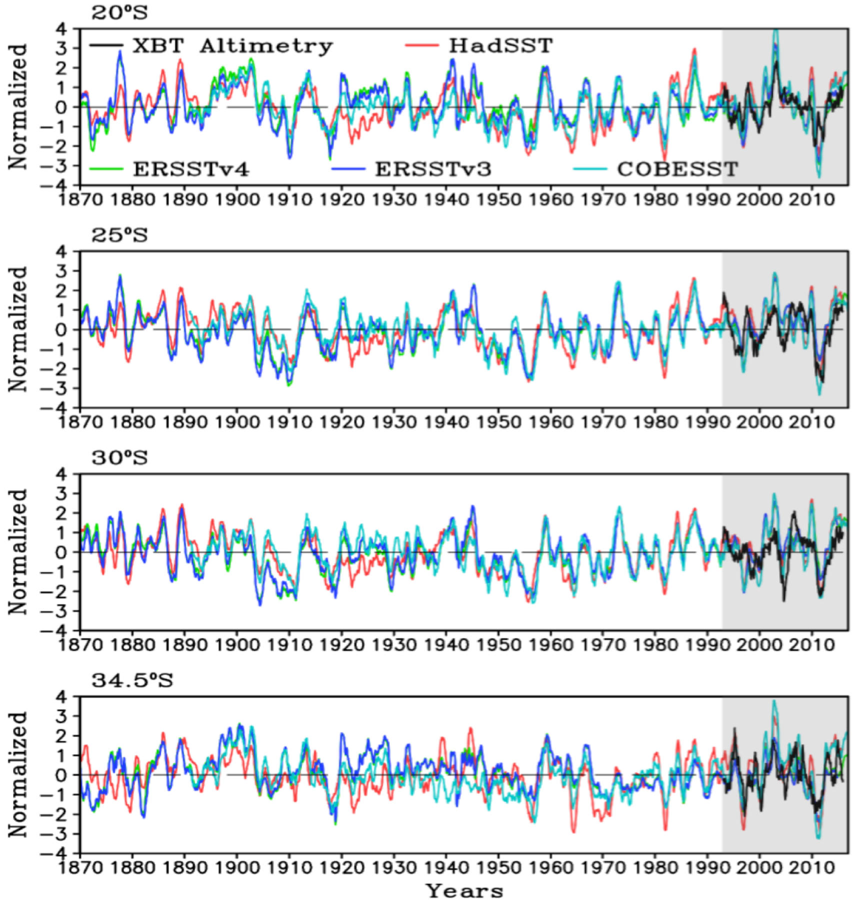
Century-Long AMOC Indices For Extreme Weather and Climate Studies:

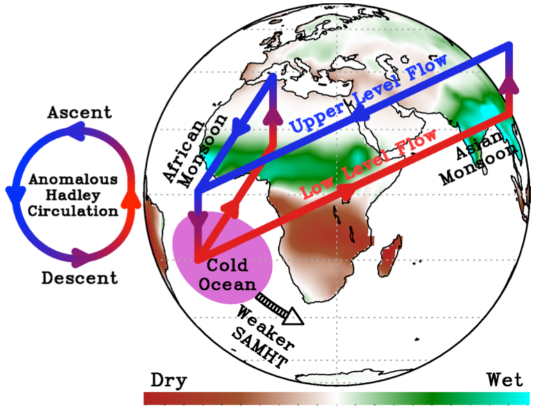
Importance of Synergy of in situ and Satellite data with climate models

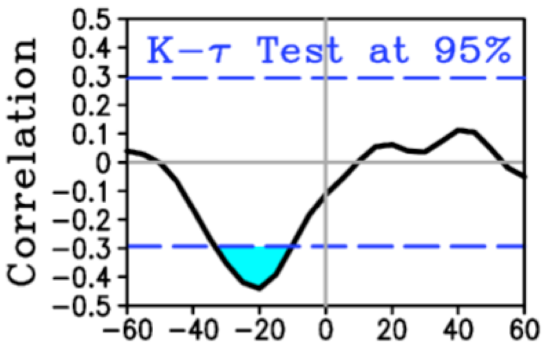


- **In situ observations: MOC estimates last ~15 years at several latitudes in the South Atlantic Ocean**
- **Combine with satellite measurements: extends the time series back to 1993 at multi-latitudes.**
- **Combine with historical SST records: extends the time series back to 1870.**

The century-long time series can be used to advance our understanding the impact of the AMOC on global extreme weather events and future climate changes (e.g. rainfall associated with monsoons).

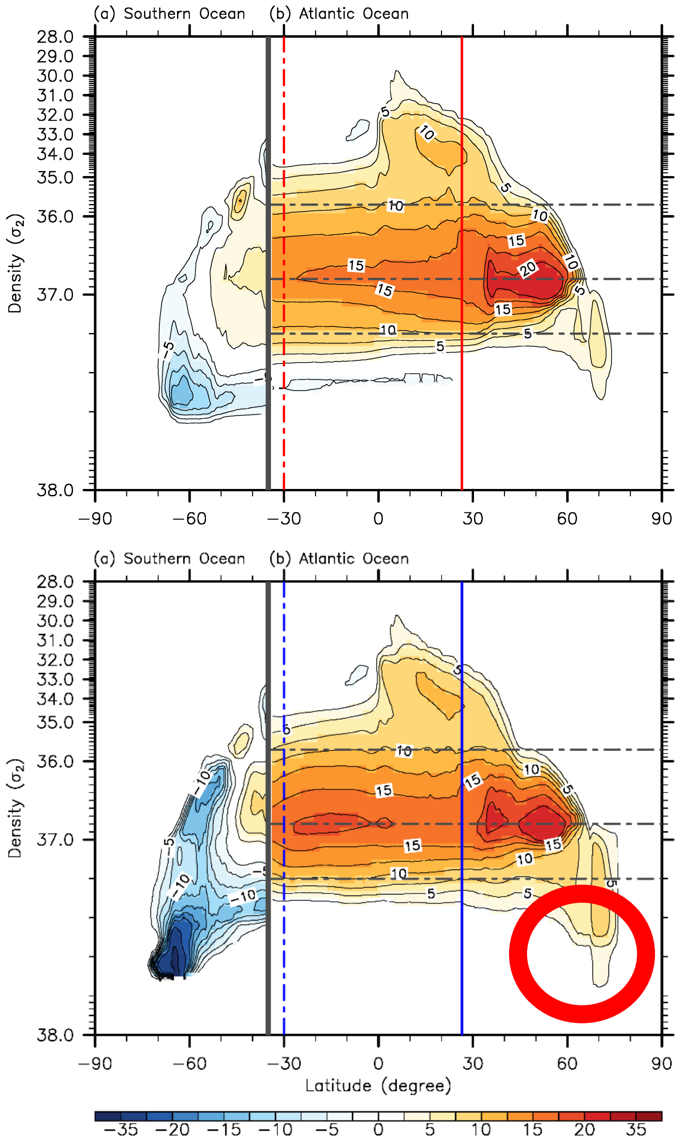






Global MOC Dsing a Data (WOA13) - Constrained CESM1 Ocean Model

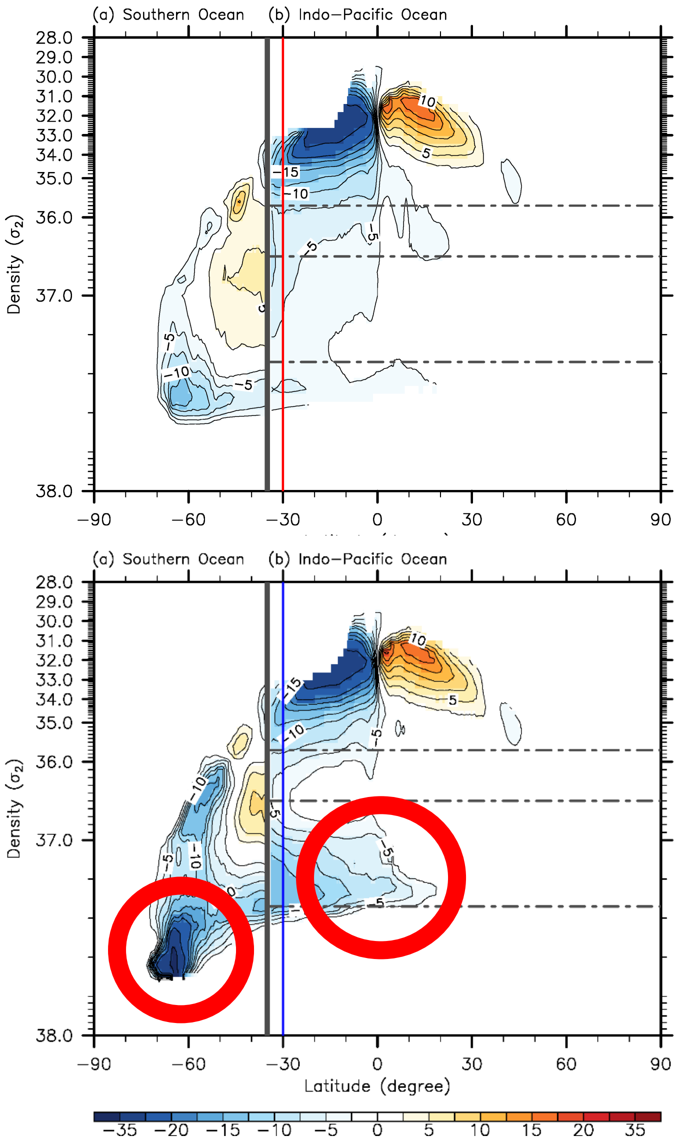
Atlantic and Southern Oceans



NCAR Ocean Model Without T-S corrections

NCAR Ocean Model With T-S Corrections

Indo-Pacific and Southern Oceans



Evaluation of NCAR Community Earth System Model 1 (CESM1).

Constraining model with WOA13 data serves to better represent the ocean.

High density waters are not formed in the southern oceans without T-S constrains

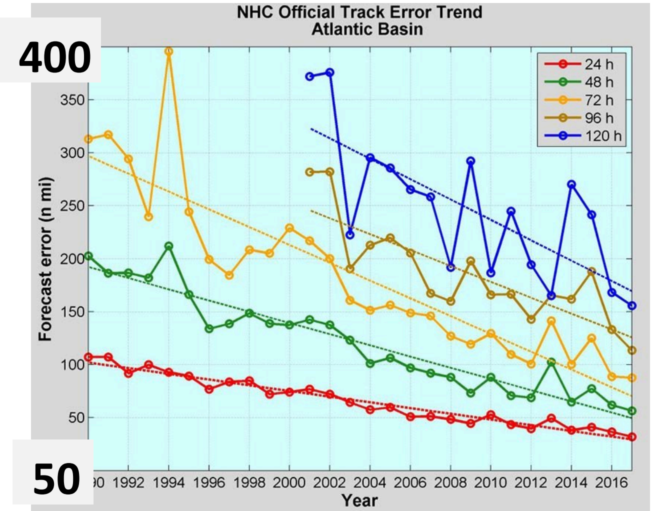
North Atlantic water is formed in the GIN Sea with T-S constrains.

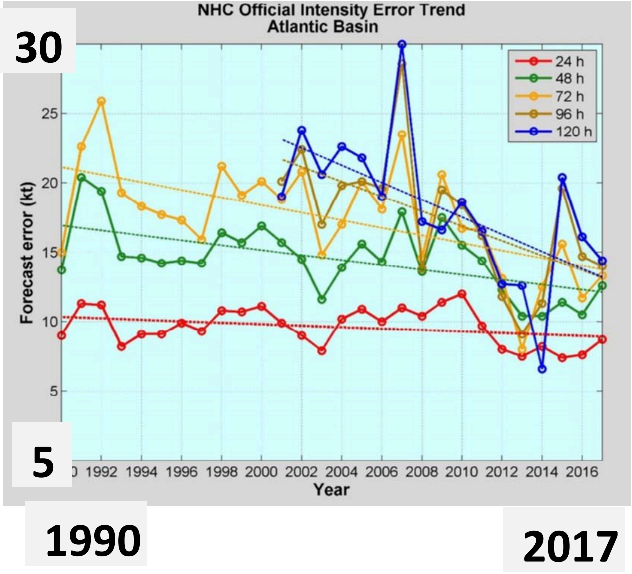
Next step is to couple CESM1 with atmospheric model

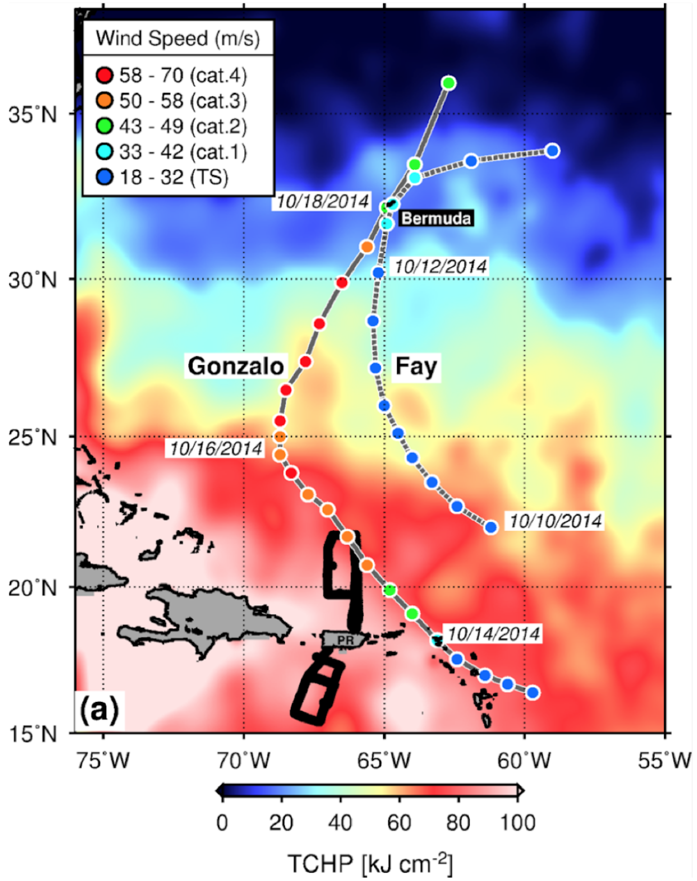
Lee et al. 2018

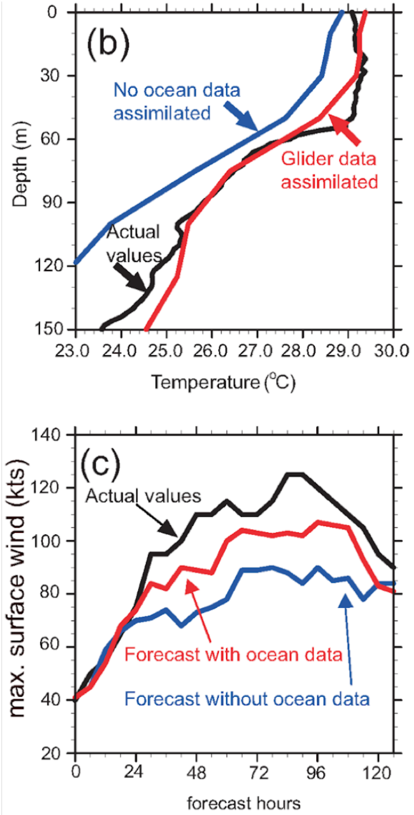
NOAA hurricane underwater gliders

Evaluation of ocean data impact









Goni et al, 2016

Atlantic hurricane forecasts have not improved in the last 10 years.

Correct ocean representation missing in models.

Data denial (aggregation) experiments to assess impact of data (OSE).

Future work will be to design an optional, efficient, logistically possible ocean observing system (OSSE) for tropical Atlantic hurricanes.

Few Research Topics in which AOML can Help

- Assess the impact of in situ and satellite observations to monitor variability of 1) Boundary currents, 2) Meridional Heat Transports.
- Carry out OSSEs to determine optimal observing systems to monitor Meridional Heat Transports.
- Deep ocean changes, coherence and fingerprints (T, S, MOC and expanding to BGC) and improving model representation.
- Near surface processes setting barrier layers in the Tropics (particularly in summer; hurricanes).
- Assess physical links between ocean variability (e.g. in the South Atlantic) and global extreme weather events (tornadoes, hurricanes, rainfall, …).
- Assess attributions to sea level changes to improve tidal forecasts, particularly impact of regional ocean current and ocean heat content (East Coast Sea Level Rise Workshop).
- Regional projections of changes and their influence on economically important and managed species (fish, corals, etc)